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Implications of a possible 115 GeV supersymmetric Higgs boson on detection and cosmological abundance of relic neutralinos

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Abstract

We show that a supersymmetric neutral Higgs boson with a mass of about 115 GeV and with the other prerequisites required by the LEP Higgs events would be compatible with the detection of relic neutralinos in current set–ups for WIMP direct search. Thus this putative Higgs would fit remarkably well in an interpretation in terms of relic neutralinos of the annual–modulation effect recently measured in a WIMP direct experiment. We also show that the cosmological abundance of the relevant neutralinos reaches values of cosmological interest.

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I. INTRODUCTION

Recent LEP data at center-of-mass energy above 206 GeV have provided a hint for a Higgs boson with a mass of about 115 GeV [1]. The analysis presented in Ref. [1] refers to a Standard Model (SM) Higgs. However, the very fact that the mass of this putative neutral boson is relatively light entails the possibility for this particle to be a neutral Higgs boson in the framework of a supersymmetric extension of the SM; in fact a light Higgs is just what one would expect in a susy scheme [2].

The existence of a susy neutral Higgs with a mass of about 115 GeV would have important consequences for various aspects [3]; in the present paper we analyze its possible implications for dark matter. We prove that a susy neutral Higgs boson with a mass of 115 GeV and with the other prerequisites required by the LEP Higgs events would be quite adequate to make scattering processes of relic neutralinos off nuclei detectable in the current apparata for WIMP direct search [4–6]. We recall that, taking into account the present uncertainties in astrophysical quantities, the sensitivity of the current experiments for WIMP direct measurements, in the WIMP mass range: 40 GeV $\leq m_\chi \leq$ 200 GeV, may be established to be [7]

$$4 \cdot 10^{-10}\ \mathrm{nbarn} \leq \xi \sigma_{\mathrm{scalar}}^{(\mathrm{nucleon})} \leq 2 \cdot 10^{-8}\ \mathrm{nbarn}, \tag{1}$$

where $\sigma_{\mathrm{scalar}}^{(\mathrm{nucleon})}$ is the scalar WIMP–nucleon scattering cross section and $\xi \equiv \rho_\chi/\rho_l$ (ρ_l is the local value for the non–baryonic dark matter; we recall that the range for ρ_l is 0.2 GeV cm^{-3} $\leq \rho_l \leq$ 0.7 GeV cm^{-3} [8]). This applies to WIMPs which interact with nuclei dominantly by coherent effects, and with equal strength with neutrons and protons. In this note we show that the putative susy Higgs would fit remarkably well in an interpretation of the annual–modulation effect measured in WIMP direct searches [5] in terms of relic neutralinos [7,9,10]. We also derive that the cosmological abundance of the relevant neutralinos reach values of cosmological interest.

Since the analysis of the recent LEP data in terms of susy Higgs bosons by the LEP Collaborations is not available yet, we perform here an independent, approximate estimate of the susy configurations which would be involved in the LEP Higgs events. Our derivation makes use of a number of simplifying assumptions, but, we believe, it is adequate to outline the quite intriguing perspectives of the relevant scenario. Refinements of our present discussion will be feasible, once the results of the susy analysis of the Higgs events by the LEP experimental Collaborations are available.

II. A SUPERSYMMETRIC INTERPRETATION OF THE LEP HIGGS EVENTS

In Ref. [1] it is shown that the LEP Higgs events at center-of-mass energy $\sqrt{s}$ above 206 GeV are compatible with the SM predictions for a SM Higgs with a mass of about 115 GeV. Here we determine the supersymmetric configurations which, in the Minimal Supersymmetric Extension of the Standard Model (MSSM), could provide events of the same topologies at approximately the same rates as in the standard model.

In the standard model the Higgs particle H_0 may be produced in e^+e^- collisions either by Higgs–strahlung: $e^+e^- \to ZH_0$, or by WW fusion: $e^+e^- \to \nu_e\bar{\nu}_e H_0$ [11]. In the present

paper we only consider events with $\bar{q}q\bar{b}b$ final states, then the WW fusion mechanism is not considered here.

The main mechanisms for production of the neutral Higgs bosons: h, A, H of the MSSM at LEP2 are Higgs–strahlung: $e^+e^- \to Zh$ (or ZH) and associated pair production: $e^+e^- \to Ah$ (or AH). Here h and H are the lighter and the heavier CP-even Higgs boson, respectively, and A is the CP-odd one. The cross sections for these processes are related to the SM cross–section for Higgs–strahlung, σ_{SM}, by the formulae [12,13]

$$\sigma(e^+e^- \to Zh) = \sin^2(\alpha - \beta)\sigma_{SM} \tag{2}$$

$$\sigma(e^+e^- \to Ah) = \cos^2(\alpha - \beta)\bar{\lambda}\sigma_{SM}, \tag{3}$$

where $\bar{\lambda} = \lambda_{Ah}^{3/2}/[\lambda_{Zh}^{1/2}(12{m_Z}^2/s + \lambda_{Zh})]$ and $\lambda_{ij} = [1 - (m_i + m_j)^2/s][1 - (m_i - m_j)^2/s]$. The cross sections for production of H are derived from those for production of h (Eqs. (2,3)), by interchanging $\sin^2(\alpha - \beta)$ with $\cos^2(\alpha - \beta)$.

The CP–even Higgs bosons are defined, in terms of the neutral components of the original Higgs doublets, as

$$H = \cos\alpha H_1^0 + \sin\alpha H_2^0 \tag{4}$$

$$h = -\sin\alpha H_1^0 + \cos\alpha H_2^0 \tag{5}$$

In the diagonalization of the mass matrix we impose the mass hierarchy: $m_h < M_H$ and take the angle α in the range $[-\frac{\pi}{2}, +\frac{\pi}{2}]$. The angle β is defined, as usual, as the ratio of the two Higgs vev's: $\tan\beta = < H_2^0 > / < H_1^0 >$.

We now consider the various possibilities for having, within the MSSM, a final state $\bar{q}q\bar{b}b$ with the properties of the relevant LEP Higgs events [1]: we require that the particle generating the pair $\bar{q}q$ has a mass of 91 GeV (this, in turn, could be either a Z in a Higgs–strahlung process, or an h, or an A in an associated pair production), and that the particle generating the pair $\bar{b}b$ has an invariant mass of 115 GeV (this, in turn, may be any of the three neutral Higgs bosons).

Notice that, from LEP searches at lower center-of-mass energies [14], an h or an A Higgs boson with a mass of 91 GeV is already excluded for low values of $\tan\beta$, and is quite close to the boundary of the allowed 90% C.L. region for large values of $\tan\beta$. We obviously take these limits into account in our analysis. Therefore, the associated production topologies are possible only for large $\tan\beta$, and also in this case they are borderline. We choose to include them anyway, whenever they are possible.

To allow for experimental uncertainties in the reconstructed invariant masses, a variation of $\pm$ 2 GeV is added to the $\bar{b}b$ Higgs invariant mass of 115 GeV. For the same reason, we consider an uncertainty also for the $\bar{q}q$ invariant mass associated to a Higgs boson (i.e., in the associated production channels), but anyway including the above mentioned lower limits on the susy Higgs masses [14].

Then we can list the following independent categories of susy events which can be considered to be compatible with the relevant LEP Higgs events (other categories are not possible for the given topologies and required mass assignments):

(1) $e^+ + e^- \to Z + h \to (\bar{q}, q) + (\bar{b}, b)$, with the conditions that $m_h = 115 \pm 2$ GeV (the $\bar{q}q$ pair is associated to the Z, while the $\bar{b}b$ pair is associated to the h boson);

(2) $e^+ + e^- \to h + A \to (\bar{q}, q) + (\bar{b}, b)$, with the conditions that $m_h = (91 \div 93)$ GeV and $m_A = 115 \pm 2$ GeV (the $\bar{q}q$ pair is associated to the h boson, while the $\bar{b}b$ pair is associated to the A boson);

(3) $e^+ + e^- \to Z + H \to (\bar{q}, q) + (\bar{b}, b)$, with the conditions that $m_H = 115 \pm 2$ GeV (the $\bar{q}q$ pair is associated to the Z, while the $\bar{b}b$ pair is associated to the H boson);

(4) $e^+ + e^- \to Z + h, Z + H \to (\bar{q}, q) + (\bar{b}, b)$, with the conditions that $m_h, m_H = 115 \pm 2$ GeV (the $\bar{q}q$ pair is associated to the Z, while the $\bar{b}b$ pair is associated either to the h or the H boson);

(5) $e^+ + e^- \to h + A, Z + H \to (\bar{q}, q) + (\bar{b}, b)$, with the conditions that $m_A, m_H = 115 \pm 2$ GeV and $m_h = (91 \div 93)$ GeV (the $\bar{q}q$ pair is associated to the h or the Z, while the $\bar{b}b$ pair is associated either to the A or to the H boson);

(6) $e^+ + e^- \to Z + H, A + H \to (\bar{q}, q) + (\bar{b}, b)$, with the conditions that $m_A = (91 \div 93)$ GeV and $m_H = 115 \pm 2$ GeV (the $\bar{q}q$ pair is associated to the Z or to the A, while the $\bar{b}b$ pair is associated to the H boson).

Since the LEP Higgs events are at the level of the SM predictions we extract the compatible supersymmetric configurations by requiring that the expected susy predictions are at this same level, within an uncertainty of 20%. For instance, in case (1) we impose that

$$0.8 \leq \sin^2(\alpha - \beta) \frac{BR_{\rm MSSM}(h \to \bar{b}b)}{BR_{\rm SM}(H_0 \to \bar{b}b)} \leq 1.2\,, \tag{6}$$

and in case (2) that

$$0.8 \leq \cos^2(\alpha - \beta) \bar{\lambda} \frac{BR_{MSSM}(h \to \bar{q}q) BR_{\rm MSSM}(A \to \bar{b}b)}{BR_{\rm SM}(Z \to \bar{q}q) BR_{\rm SM}(H_0 \to \bar{b}b)} \leq 1.2\,, \tag{7}$$

and similarly for the other cases. BR_{SM} and BR_{MSSM} denote the branching ratios in the standard model and in MSSM, respectively.

For each of the categories defined above and whenever necessary, we have checked that production channels with Higgs mass assignements outside the two ranges: $(91 \div 93)$ GeV and 115 ± 2 GeV would not produce an exceedingly large excess of events which have not actually been observed. Notice that, due to lack of analysis by the experimental Collaborations within MSSM, our analysis takes into account only a selection of events based on ranges of masses, and not other selection criteria based for instance on kinematics. A more complete analysis taking account also of the specific kinematical constraints will be feasible, once the analysis within MSSM by the LEP Collaborations are available.

We remind that the couplings of the bosons h, H and A to the up-type and down–type quarks are proportional to $m_q k_u$ and $m_q k_d$, where m_q denotes the quark mass, and the coefficients k_u, k_d are given by

	h	H	A
k_u	$\cos\alpha/\sin\beta$	$\sin\alpha/\sin\beta$	$1/\tan\beta$
k_d	$-\sin\alpha/\cos\beta - \epsilon\cos(\alpha - \beta)\tan\beta$	$\cos\alpha/\cos\beta - \epsilon\sin(\alpha - \beta)\tan\beta$	$\tan\beta(1 + \epsilon)$

In this table the entries include those radiative corrections which may be sizeable at large $\tan\beta$. These corrections affect the couplings to down–type quarks k_d, and are parametrized

in terms of the quantity $\epsilon \equiv 1/(1+\Delta)$, where Δ enters in the relationship between the fermion running masses m_d and the corresponding Yukawa couplings h_d [15]:

$$m_d = h_d < H_0^1 > (1+\Delta) \tag{8}$$

These corrections take contributions mainly from gluino–squark, chargino–squark and neutralino–stau loops [15]. Radiative corrections to the Higgs-quark couplings k_d affect the calculation of the Higgs–decay branching ratios, of the neutralino–nucleus cross section and of the neutralino cosmological relic abundance.

We notice that the correction to the relation between the b quark mass and its Yukawa coupling defined in Eq.(8) enters also in the calculations of the $b \to s + \gamma$ decay [16]. For the SUGRA model discussed below, it affects also the boundary conditions at the GUT scale for the b Yukawa coupling [17]. This in turn affects the radiative symmetry breaking mechanism and the low–energy Higgs and sfermion spectra [18]. All these effects are included in our calculations.

To derive the specific supersymmetric configurations from the previous conditions, one has to define the features of the susy scheme. In the present paper we consider two models: a SUGRA model with unification conditions at a grand unification scale (universal SUGRA) and an effective model at the electroweak scale (effMSSM) [7].

The universal SUGRA model is parametrized in terms of five parameters: the gaugino mass $m_{1/2}$, the scalar mass m_0, the trilinear coupling A_0, $\tan\beta$, the sign of the Higgs–mixing coupling μ. $m_{1/2}$, m_0 and A_0 are defined at the unification scale. In the present paper, these parameters are varied in the following ranges: 50 GeV $\leq m_{1/2} \leq$ 1 TeV, $m_0 \leq$ 3 TeV, $-3 \leq A_0 \leq +3$, $1 \leq \tan\beta \leq 50$.

The effMSSM model is given at the electroweak scale in terms of seven independent parameters: the SU(2) gaugino mass $M_2, \mu, \tan\beta, m_A$, a common mass for squarks $m_{\tilde{q}}$, a common mass for sleptons $m_{\tilde{l}}$ and A; these parameters are varied in the following ranges: 50 GeV $\leq M_2 \leq$ 1 TeV, 50 GeV $\leq |\mu| \leq$ 1 TeV, 90 GeV $\leq m_A \leq$ 1 TeV, 100 GeV $\leq m_{\tilde{q}}, m_{\tilde{l}} \leq$ 1 TeV, $-3 \leq A \leq +3$, $1 \leq \tan\beta \leq 50$ (m_A is the mass of the CP-odd neutral Higgs boson). Our scanning of the susy parameter space, both in case of universal SUGRA and of effMSSM takes also into account all available accelerator constraints, including $b \to s + \gamma$ bounds. Further details about our susy models and the ways in which the constraints are implemented may be found in Refs. [7,9].

Let us turn now to the presentation of our results about the supersymmetric configurations selected according to the criteria explained above. These are provided by Figs. 1a, 1b in terms of the angle α and of $\tan\beta$. In these figures and in all the following ones, dots denote the representative points for events of the category (1), i.e. Higgs–strahlung of h, crosses denote events of the category (3), i.e. Higgs–strahlung of H, open dots denote category (4) and finally filled dots denote category (6). We do not find solutions for categories (2) and (5) above.

The main features displayed in the plots of Figs. 1a, 1b may be understood in terms of the relations between the angles α, β and m_A, these relations arising from the diagonalization of the Higgs mass matrix. At values of $\tan\beta \sim 1$, $\sin(2\alpha) \sim -1$ and $\alpha \sim -\pi/4 \sim \beta - \pi/2$. This implies that $\sin^2(\alpha-\beta) \sim 1$ [19]. Therefore, in this case, category (1) events, i.e. Higgs–strahlung of h events, are able to reproduce the LEP Higgs events with a production

cross section at the level of the SM one. On the contrary, when $\tan\beta$ is large, $\sin(2\alpha)$ is small and $\cos(2\alpha)$ is usually close to 1, except when m_A is close to the mass of the Z boson: in this latter case, $\cos(2\alpha)$ can reach the values 1 or -1, depending on radiative correction terms. Therefore, when $\tan\beta$ increases, α can cover the whole range $(-\pi/2, \pi/2)$ (the sign depending on radiative correction terms in $\sin(2\alpha)$). When $\alpha \sim 0 \sim \beta - \pi/2$ then $\sin^2(\alpha - \beta) \sim 1$ and a situation similar to the previous one holds: the LEP data can be reproduced by Higgs–strahlung of h events. On the other hand, when $\alpha \sim \pi/2 \sim \beta$ or $\alpha \sim -\pi/2 \sim \beta - \pi$, then $\cos^2(\alpha - \beta) \sim 1$: in this case the LEP data can be reproduced by Higgs–strahlung of H events. Notice that in order to have this last possibility, we need m_A not too far from m_Z. In the effMSSM scheme, this can be achieved easily, since m_A is a free parameter. On the contrary, in a SUGRA scheme, due to radiative electroweak symmetry breaking, m_A turns out to be a decreasing function of $\tan\beta$ and it can be of the order of m_Z only for $\tan\beta \gtrsim 40$ [20,18].

We wish to stress that the occurrence of the condition $\cos(2\alpha) \sim -1$, and then $\cos^2(\alpha - \beta) \sim 1$, depends crucially on the radiative corrections employed in the Higgs sector. In the present paper we have used the results of Refs. [21].

III. RELIC NEUTRALINOS: DETECTION AND COSMOLOGICAL ABUNDANCE

We turn now to the evaluation of the elastic neutralino–nucleon cross–section $\sigma^{(\rm nucleon)}_{\rm scalar}$ and of the neutralino relic abundance $\Omega_\chi h^2$ for the susy configurations selected on the basis of the LEP Higgs events, and discussed in the previous Section. The calculations of $\sigma^{(\rm nucleon)}_{\rm scalar}$ have been performed with the formulae reported in Refs. [7,9,22]; set 1 for the quantities $m_q < \bar{q}q >$'s has been used (see Ref. [22] for definitions; set 1 is on the conservative side of the range considered in [22]); the evaluation of $\Omega_\chi h^2$ follows the procedure given in [23].

Figs. 2a, 2b display the scatter plots for $\sigma^{(\rm nucleon)}_{\rm scalar}$ versus $\Omega_\chi h^2$ for effMSSM and universal SUGRA, respectively. For universal SUGRA only the results corresponding to positive values of μ are displayed, since, for negative values, the constraint on $b \to s + \gamma$ implies a large suppression of $\sigma^{(\rm nucleon)}_{\rm scalar}$. The two horizontal lines bracket the sensitivity region defined by Eq. (1), when $\xi = 1$. The two vertical lines denote a favorite range for the cosmological matter density $\Omega_{\rm m} h^2$: $0.05 \leq \Omega_{\rm m} h^2 \leq 0.3$, as derived from a host of observational data. Notice that the most recent determinations of cosmological parameters [24] appear to pin down the matter relic abundance to a narrower range $0.08 \lesssim \Omega_{\rm m} h^2 \lesssim 0.21$. However, some caution in taking this range too rigidly is advisable, since some determinations of cosmological parameters are still subject to fluctuations. We point out that in the present paper we are not restricting ourselves to any particular interval of $\Omega_{\rm m} h^2$. Only some features of Figs. 3a, 3b depend on the actual value employed for the minimum amount of matter necessary to reproduce the halo properties correctly.

Fig. 2a shows the quite remarkable result that in effMSSM almost all susy configurations of the Higgs events of categories (3), (4), (6), and a sizeable part of those of category (1) fall in the range of detectability by current WIMP direct searches. Furthermore, part of these configurations entail neutralinos of great cosmological interest. This is also true for the SUGRA scheme of Fig. 2b.

It is interesting to examine the nature of the contributions which dominate the scalar neutralino–nucleon cross–section. Let us do it for events of the categories (1) and (3). In the case of production of an h by Higgs–strahlung, one has $\sin^2(\alpha-\beta)\sim 1$, then $|\tan\alpha|\sim 1/\tan\beta$, with the consequence that $|k_u|\sim 1, |k_d|\sim 1$ for h, and $|k_u|\sim 1/\tan\beta$, $|k_d|\sim \tan\beta(1+\epsilon)$ for H. From these properties and the fact that the coherent cross-section takes its dominant contribution from the strange-quark content of the nucleon [22], we derive that in this case $\sigma_{\rm scalar}^{\rm (nucleon)}$ is dominated (except for values of $\tan\beta$ close to 1) by exchange of an H boson, when H is relatively light and ϵ is not close to -1. However, the H boson is not bounded from above in mass and can be naturally heavy: in this case the $\sigma_{\rm scalar}^{\rm (nucleon)}$ for Higgs-exchange can become small. The situation is reversed in the case of production by Higgs–strahlung of an H. In fact, now one has $\cos^2(\alpha-\beta)\sim 1$, then $|\tan\alpha|\sim\tan\beta$, which implies $|k_u|\sim 1/\tan\beta, |k_d|\sim\tan\beta(1+\epsilon)$ for h and $|k_u|\sim 1, |k_d|\sim 1$ for H. Thus, in this case $\sigma_{\rm scalar}^{\rm (nucleon)}$ is dominated by exchange of an h, except when ϵ is close to -1. This boson is always light, and even more so here, since it has to be lighter than H, whose mass is fixed to be about 115 GeV in order to match the requirement for the LEP events; then $\sigma_{\rm scalar}^{\rm (nucleon)}$ is sizeable. It is interesting to notice that in this case, i.e. Higgs–strahlung of an H in the LEP data, where all the three susy Higgses are close in mass, also the neutralino pair–annihilation cross–section $\langle\sigma_{\rm ann}v\rangle$, which is responsible for the relic abundance, is dominated by Higgs exchange, namely by A–exchange into fermions, mostly $\bar{b}b$ pairs. Since the dominant couplings to neutralinos and to fermions of both h and A are similar ($\cos^2(\alpha-\beta)\sim 1$ and large $\tan\beta$), it is easy to show that $\langle\sigma_{\rm ann}v\rangle/\sigma_{\rm scalar}^{\rm (nucleon)}\sim 1.7\cdot 10^2(M/{\rm GeV})^2r^2/(4r^2-1)^2$, where $r=m_\chi/M$ and M denotes a common mass scale for the three Higgs masses. For the neutralino masses of interest here, $m_\chi\sim M\sim 100$ GeV, the relic abundance is therefore easily expressed as a function of $\sigma_{\rm scalar}^{\rm (nucleon)}$ as: $\Omega_\chi h^2\sim 4\cdot 10^{-10}/(\sigma_{\rm scalar}^{\rm (nucleon)}/{\rm nbarn})$. This implies that relic abundances of the order of 0.1 are obtained with $\sigma_{\rm scalar}^{\rm (nucleon)}$ of the order of a few $\times 10^{-9}$ nbarn, as it is shown by the cross symbols in Figs. 2a and 2b.

We turn now to a comparison of our results with specific experimental measurements. To do this we plot in Figs. 3a, 3b the quantity $\xi\sigma_{\rm scalar}^{\rm (nucleon)}$ versus m_χ. ξ is taken to be $\xi=\min\{1,\Omega_\chi h^2/(\Omega_{\rm m}h^2)_{\rm min}\}$, in order to have rescaling in the neutralino local density, when $\Omega_\chi h^2$ turns out to be less than $(\Omega_{\rm m}h^2)_{\rm min}$ (here $(\Omega_{\rm m}h^2)_{\rm min}$ is set to the value 0.05).

In Figs. 3a, 3b the solid line denotes the frontier of the 3σ annual–modulation region of Ref. [5], when the uncertainties in ρ_l and in the dispersion velocity of a Maxwell–Boltzmann distribution, but not the ones in other astrophysical quantities, are taken into account. Effects due to a possible bulk rotation of the dark halo [25,26], or to an asymmetry in the WIMP velocity distribution [27–29] would move this boundary towards higher values of m_χ.

We note that Figs. 3a, 3b show that the annual–modulation effect of Ref. [5] is quite compatible with supersymmetric configurations involved in the LEP Higgs events.

IV. CONCLUSIONS

Motivated by the intriguing results of the LEP Collaborations about a hint for a possible neutral Higgs with a mass of about 115 GeV, we have considered what might be the consequences for dark matter, in case the LEP Higgs events are interpreted as due to super-

symmetric neutral Higgs bosons in a Minimal Supersymmetric Extension of the Standard Model.

Using two extreme susy schemes, a universal SUGRA and an effective scheme at the electroweak scale (effMSSM), we have proved that the supersymmetric configurations extracted from the LEP data are compatible with relic neutralinos of cosmological interest and of relevance for the current WIMP direct searches. Quite remarkably, the analyzed susy configurations would fit the annual–modulation effect of Ref. [5]. It is obvious that the same conclusions apply for susy SUGRA schemes where some of the unification conditions at the grand unification are partially relaxed (non–universal SUGRA schemes).

Various cautionary comments are in order here. First, the effect seen at LEP is only at a significance of 2.9 σ , and no confirmation (or disproof) of this most relevant subject will unfortunately be available for quite a long time. Secondly, a detailed analysis of the current LEP data in terms of susy Higgs bosons has still to be completed by the LEP Collaborations; once this is available, some of the estimations performed in our Sect. II might be subject to refinements.

The very nature of the LEP Higgs data necessarily confers to any analysis of these results a somewhat speculative character. However, due to the important properties at stake, it is very intriguing to work out the various ensuing possible scenarios. Our analysis shows that a quite coherent picture for supersymmetry and particle dark matter may come out from the merging of quite independent observations: measurements at accelerators and detection of relic particles around us.

V. NOTE ADDED

After submission of our paper a new accurate experimental determination of the muon anomalous magnetic moment appeared (H.N. Brown et al., hep-ex/0102017). This data, if compared with theoretical evaluations in M. Davier and A. Höcker, Phys. Lett. B435, 427 (1998), would show a deviation of 2.7 σ. This has determined an outburst of theoretical papers where this possible deviation is attributed to supersymmetry, and the relevant implications are derived. However, as pointed out in F.J. Ynduráin, hep-ph/0102312, other standard–model evaluations of a_μ are in fair good agreement with the experimental data. Thus, for the time being, it appears safer to use these data as a constraint on supersymmetry, rather than a sign of it. Employing the set of theoretical results reported in F.J. Ynduráin, hep-ph/0102312, we find that the contribution of supersymmetry to the anomalous moment is constrained by $-600 \leq a_\mu^{susy} \cdot 10^{11} \leq 800$. This constraint has been implemented in our scanning of the supersymmetric parameter space.

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FIGURES

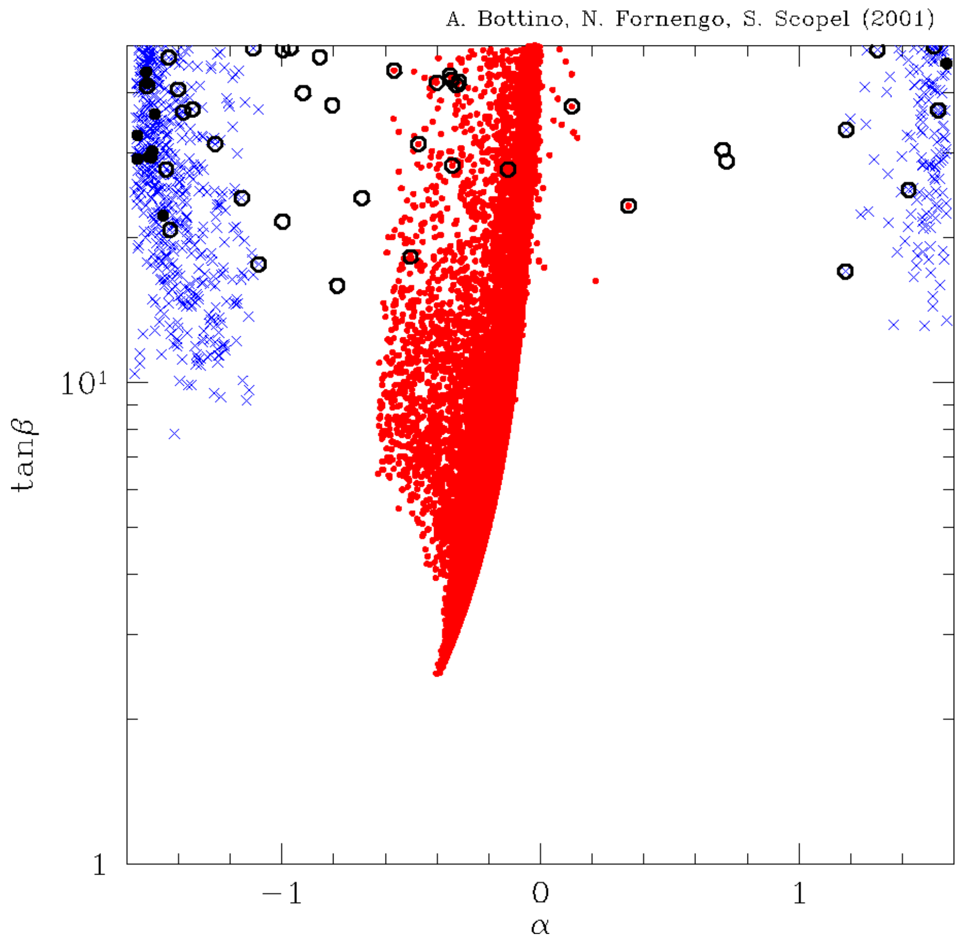

FIG.1a - Supersymmetric configurations selected according to the criteria for reproducing the relevant LEP Higgs events in the effMSSM, shown in the plane $\tan\beta$ vs. α. Different points refer to different categories of events: dots refer to $e^+ + e^- \to Z + h \to (\bar{q}, q) + (\bar{b}, b)$, crosses refer to $e^+ + e^- \to Z + H \to (\bar{q}, q) + (\bar{b}, b)$, open dots refer to $e^+ + e^- \to Z + h, Z + H \to (\bar{q}, q) + (\bar{b}, b)$ and finally filled dots refer to $e^+ + e^- \to Z + H, A + H \to (\bar{q}, q) + (\bar{b}, b)$.

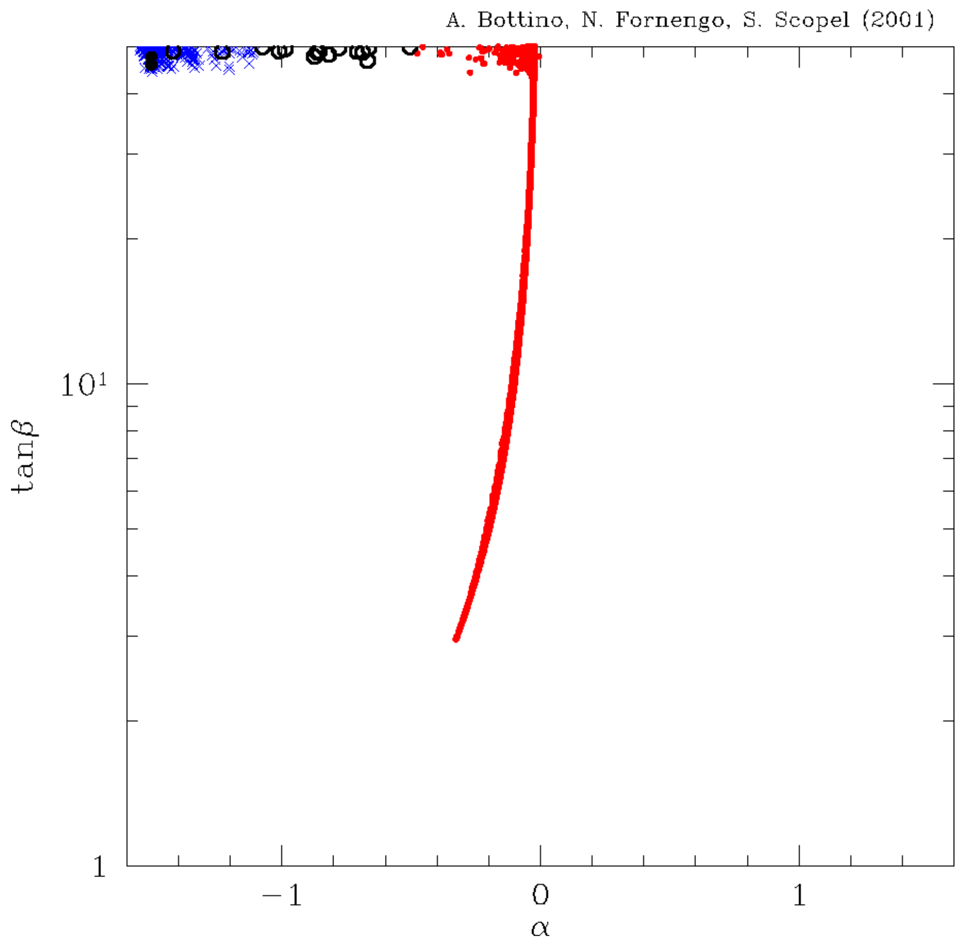

FIG.1b - Supersymmetric configurations selected according to the criteria for reproducing the relevant LEP Higgs events in universal SUGRA. Notations as in Fig.1a.

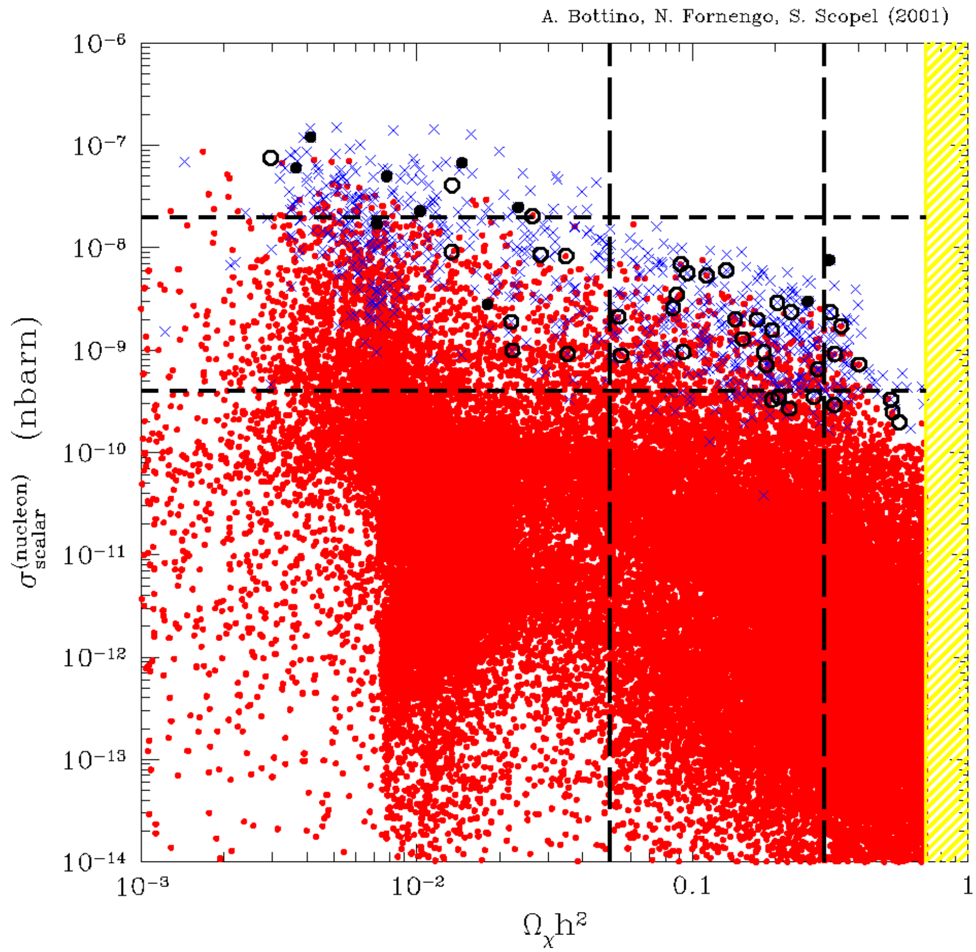

FIG.2a - Scatter plot of the neutralino–nucleon scalar cross section $\sigma_{\rm scalar}^{\rm (nucleon)}$ versus the neutralino relic abundance $\Omega_\chi h^2$ for the effMSSM. Set 1 for the quantities $m_q < \bar{q}q >$'s is employed in the calculation of $\sigma_{\rm scalar}^{\rm (nucleon)}$. The two horizontal lines bracket the sensitivity region defined by Eq. (1). The two vertical lines denote the range $0.05 \leq \Omega_{\rm m} h^2 \leq 0.3$. The region where $\Omega_\chi h^2 > 0.7$ is excluded by current limits on the age of the Universe. Different points (notations as in Fig.1a) refer to different categories of events able to reproduce the relevant LEP Higgs events.

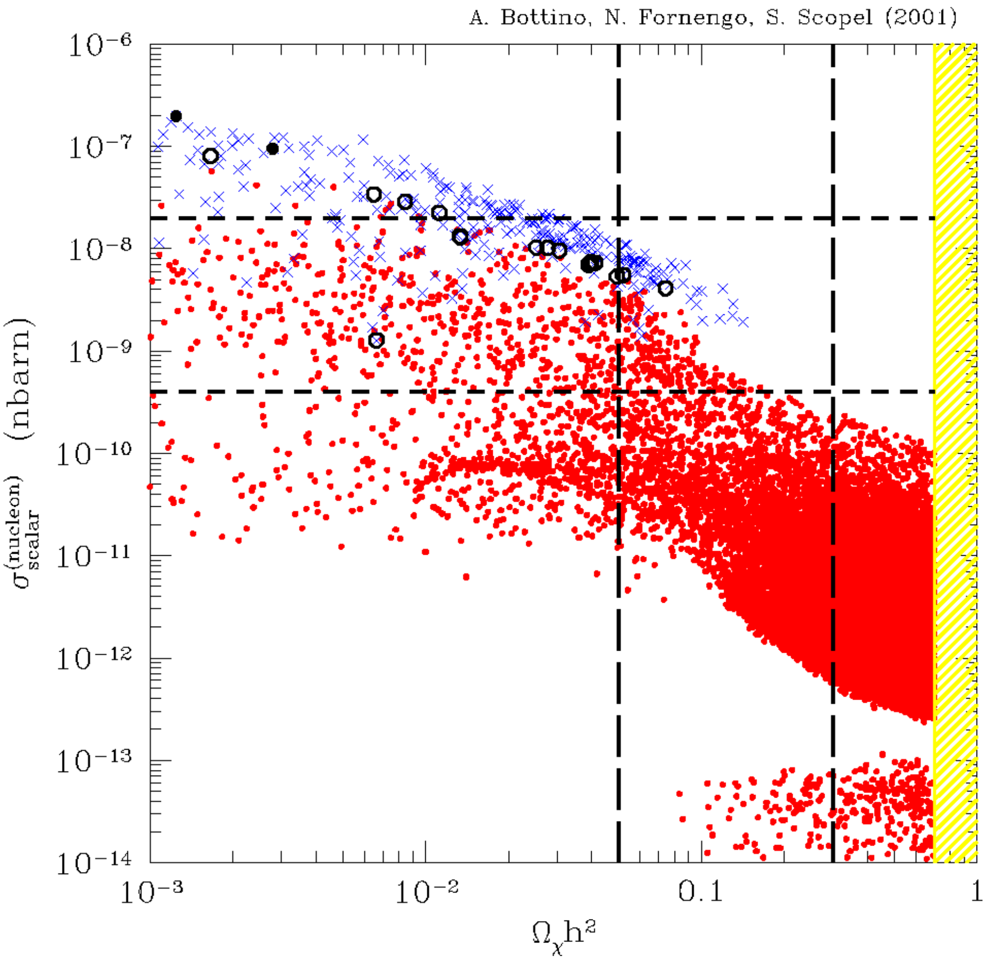

FIG.2b - Scatter plot of the neutralino–nucleon scalar cross section $\sigma_{\rm scalar}^{\rm (nucleon)}$ versus the neutralino relic abundance $\Omega_\chi h^2$ for universal SUGRA. Notations and definitions as in Fig.2a.

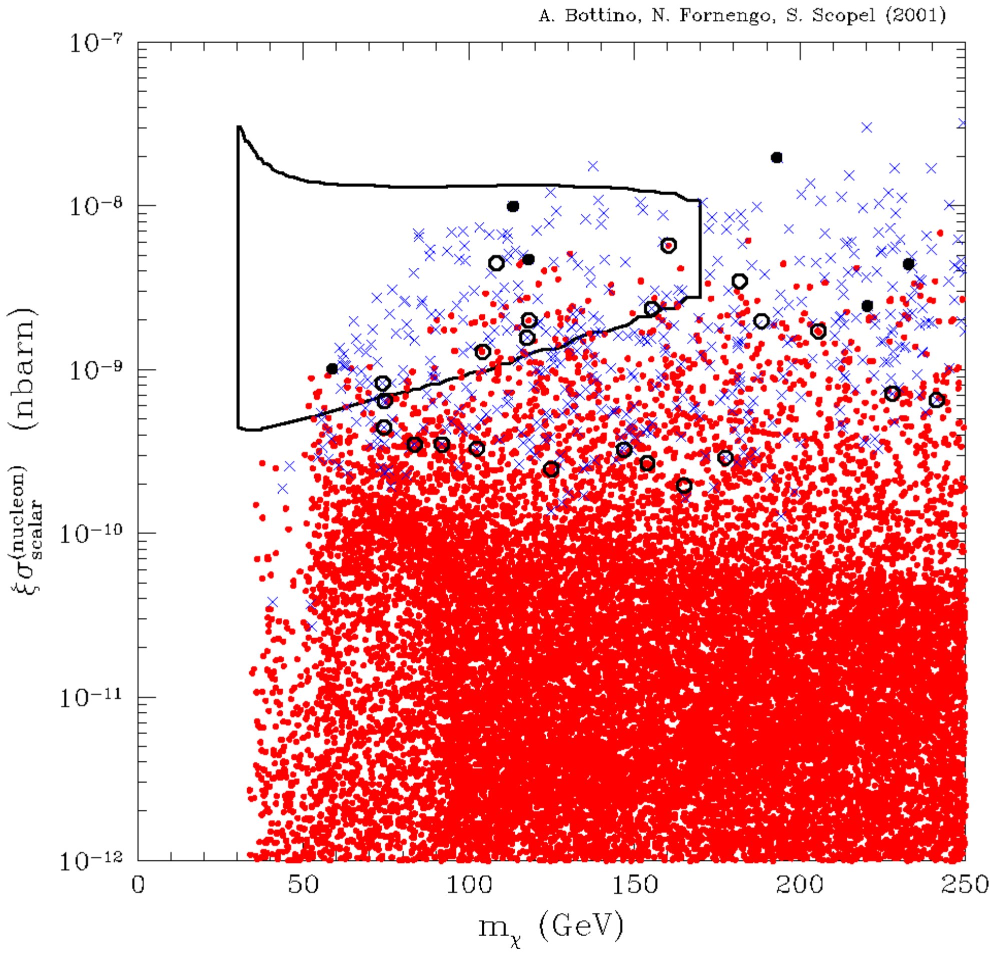

FIG.3a - Scatter plot of $\xi\sigma_{\rm scalar}^{\rm (nucleon)}$ versus the neutralino mass m_χ for the effMSSM. Set 1 for the quantities $m_q < \bar{q}q >$'s is employed in the calculation of $\sigma_{\rm scalar}^{\rm (nucleon)}$. Different points (notations as in Fig.1a) refer to different categories of events able to reproduce the relevant LEP Higgs events. The solid contour denotes the 3σ annual–modulation region of Ref. [5] when taking into account the uncertainties in the local dark matter density and in the dispersion velocity of the velocity distribution function of WIMPs in the galactic halo.

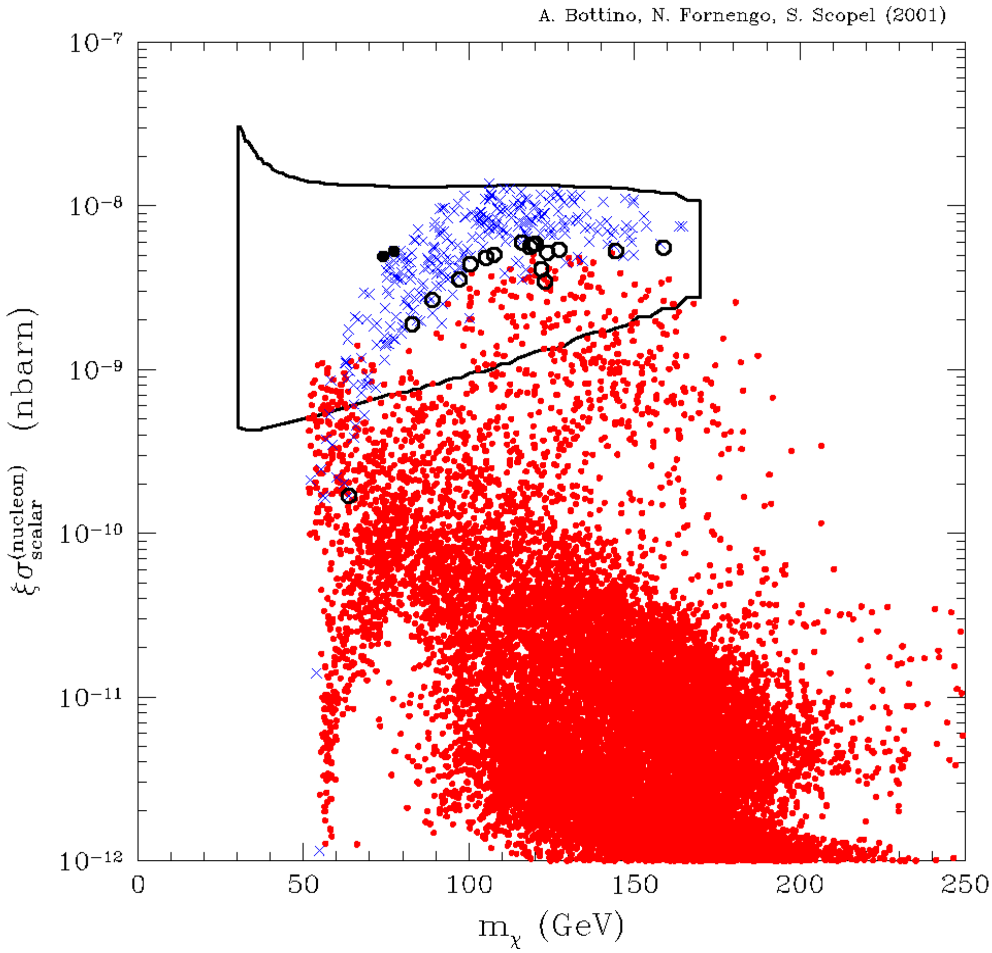

FIG.3b - Scatter plot of $\xi\sigma_{\rm scalar}^{\rm (nucleon)}$ versus the neutralino mass m_χ for universal SUGRA. Notations and definitions as in Fig.3a.